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METHODS FOR CONTROLLING OR LIMITING THE DEVELOPMENT OF MICROORGANISMS IN PETROLEUM PRODUCTS

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Abstract

In the article, review of the literature on the subject currently used methods of controlling or limiting the development of microorganisms in petroleum products was made. The problem of microbial contamination in petroleum products was presented, which is still valid and is becoming more common. In the article, microbiological contaminants present in petroleum products were described. In the following part of the article the various methods of combating microbial contamination in petroleum products, which include physical methods, thermal disinfection and chemical methods were presented. In due to the limited use of physical methods, the article focused on methods widely disseminated. Combating harmful microorganisms using a biocide were described, which due to their harmful effects on beneficial microorganisms and the environment are becoming more and more limited use. Because of their harmful effects on beneficial microorganisms and the environment, their use is becoming more limited. Furthermore, another method of controlling microorganisms during storage of the fuel by means of cleaners that help to eliminate the water, reducing sludge was presented. Apart from the measures to combat microorganisms and additives of cleaning properties, the simplified methods for determining the amount of microorganisms in the fuel using the kits containing the finished substrate suitable for growth of microorganisms are described. These kits allow the monitor the status of microbial petroleum products and thus help prevent many crashes. In the final part of the article authors proposed other ways to control or limit microbial growth are presented. The work conclusions were completed. The most important is that there is a need to develop effective methods of combating microbial contamination of fuels and oils by means of measures environmentally friendly.

Keywords: *petroleum products, microbiological contamination, microorganisms, biocides, fuel, oil*

1. Introduction

Crude oil and its refined products and petrochemicals are one of the most important sources of energy, fuel and raw materials, without which human life and its further development would be very difficult and complicated. With its irrational gaining and processing can pose various risks leading to major accidents, disasters and accidents [8].

With the development of industry and the wider automotive industry, which also includes aircraft and ships, it turned out that the problem of microbial contamination is still valid and is becoming more widespread. Studies have shown that microbial activity can lead to interference and even damage engines of vehicles, aircraft or ships [5, 2].

Currently, there are different ways to combat microbial contamination in petroleum products, which include physical methods, thermal disinfection and chemical methods. Therefore, the physical and thermal methods are not very effective, and the use of highly concentrated chemical substances, which are harmful to the environment, it is necessary to develop effective methods for combating microbial contamination of fuels and oils. These methods should take into account both the technical aspects and the specifics of the processes occurring in the fuel and lubricating systems by means of which will be environmentally friendly [6].

2. Petroleum products – general information

Crude oil as a source of energy is a liquid, a natural mixture of hydrocarbons alkane, cycloalkane and arene. Petroleum additives are also organic compounds of sulphur, nitrogen and oxygen, as well as mineral substances and water.

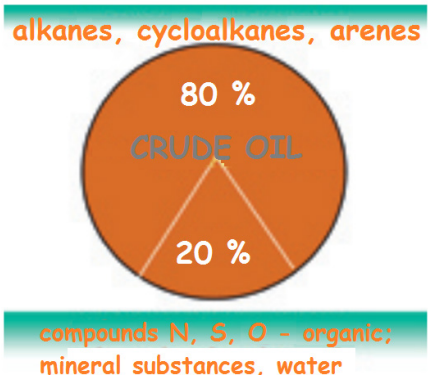

Fig. 1. The main components of crude oil [8]

Many types of bacteria and fungi have the ability to grow in petroleum products, using the above-mentioned components as a carbon and energy source. The result of life activity of microorganisms is the distribution of hydrocarbons and additives and the release of the product petroleum metabolites: water, sulphur compounds, surface-active substances. This causes changes in the chemical composition of the product oil and affects the values of certain physical parameters, such as boiling point, acid number, and viscosity. Biofilm forming on the metal surfaces creates conditions especially conducive to corrosion processes of fuel tanks and fuel or lubricating system [6, 9].

3. Microbial contamination of petroleum products

Considering the microbiological contamination of petroleum products, there are three categories of microbial decomposition of petroleum products [3, 5]:

- the first relates to microbial decomposition products used in diesel engines; the aqueous phase has a small volume relative to the oil phase. These processes occur on merchant ships and naval vessels, and also in aircraft, including ultrasonic and offshore platforms,
- the second category is when limited aqueous phase is in contact with the oil phase, or while it is dispersed, and the contact is long lasting. These processes occur in lubricating oils, hydraulic fluids and cooling lubricants used during the processing of metal machining,
- the third category relates to the emulsion oil in water system in which it is diluted. These are oils for rolling mills, steel and aluminium.

Fuel of good quality must be clear and transparent. Growth of microorganisms often can contribute to its clouding and discoloration. The most obvious and easy to get to know the consequence of microbial activity is the formation of deposits, visible as solid particles. They represent a mixture of live and dead cells, and inorganic products.

3.1. Microorganisms in petroleum products

Aviation gasoline is used to drive the piston aircraft engines. They are obtained by mixing a gasoline base with high-octane components (isoparaffinic hydrocarbons, alkylaromatic hydrocarbons). Aviation fuels are used to drive the jet engines. They represent a crude oil distillation fraction. First microbes of aviation gasoline were isolated in 1945 year and 13 years later – with

aviation fuel. Then the addition of lecithin was proposed to eliminate the growth of microorganisms in aviation gasoline. After some time it appeared that the presence of lecithin, which is an easily assimilated source of food caused more intensive proliferation of microorganisms.

Diesel oils are mixtures of liquid hydrocarbons, mainly alkanes. Often they contain carbon, hydrogen, sulphur. The basic raw materials for obtaining fuel oils are suitable crude oil distillates. They are used as liquid fuels for combustion engines with compression ignition. It stands out for high-speed diesel engines – diesel fuel, and medium- and low-speed marine engines. They differ mainly viscosity, pour point, sulphur content and other characteristics [10]. Symptoms of the presence of microorganisms in automotive diesel and conditions of their development are similar to those described previously aviation fuels. Among other diesel oil were tested. It was found in all tanks among other sulphate reducing bacteria, which are responsible for the processes of pitting corrosion of internal metal tanks. The studies confirmed the risks arising from the presence of microorganisms in the fuel tanks of diesel.

Like the fuel and aviation gasoline, also there is a negative impact of microorganisms in diesel fuels used in maritime transport. The presence symptoms of the microbial oils are similar to those occurred in the aviation fuels. There may be present in turbidity and the presence of a suspension in oil and corrosion of tanks, which result from the activity of sulphate-reducing bacteria.

Motor gasoline is a mixture of liquid paraffinic, naphthenic, aromatic and unsaturated present in varying ratios. The conditions for microbial growth in gasoline, as well as the effects caused by their presence are similar to those previously described. The study shows that the tanks with petrol, including unleaded petrol, in the bottom layers were microbiologically contaminated. The use of unleaded gasoline, as well as eco-diesel fuels, will be a problem, probably because they are more susceptible to microbial degradation than gasolines containing lead compounds [4, 5].

4. Methods of combating microorganisms in petroleum products

An important element is the prevention and protection of petroleum products against microbial contamination. Such protection may include physical methods, such as sedimentation, filtration and disinfection fuel thermal and chemical method.

Physical methods are less burdensome for the environment, but unfortunately, their use is limited, inter alia, for this reason that it cannot be used with their help decontamination, e.g. tanks. For this reason, other methods are used, for example, the use of compounds of synthetic or natural origin for combating harmful organisms called biocides. They are also used cleaners XBee during storage of fuel, to help eliminate water, reducing sediments such as rust.

4.1. Combating microorganisms by the use of biocides

Biocides are pesticides used among other for combating or reducing the development of microorganisms in petroleum products.

We can distinguish biocides, which are soluble in fuels to protect the oil phase and water soluble to decontaminate the vessels.

Currently, the most commonly used biocides in the protection of petroleum products include isothiazolone biocides and N – trihalometylotione and various polymeric analogues of quaternary ammonium salts. The structural formulas these compounds were presented in Fig. 2.

In combating microorganisms in marine fuels during storage and transport until the consumption of a number of principles must be observed. This amounts mainly to minimize the amount of water in the tanks, as well as in the fuel.

It is important that the correct dosage of biocides. Too small amounts of biocides may lead to immunization of microorganisms, and therefore, consequently, the use higher and higher doses in order to ensure the expected performance.

Unfortunately, most of biocides also destroy beneficial organisms and cause adverse changes in the composition of microorganisms. Despite the many benefits, it is currently a strong trend to reduce the use of biocides [5]. They are caused by the fear of the harmful effects of highly concentrated substances on the environment [1, 7].

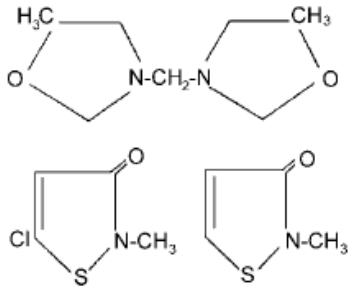

Fig. 2. The structural formulas of biocides [5]

4.2. Combating microorganisms using special kits

Another currently used method of combating microorganisms during storage of the fuel is cleaner XBee that helps eliminate water, limiting sediments such as rust. The fuel additive XBee also reduces contamination in humid fuels. This is the result of biological biomass (yeasts, moulds, fungi), which develops in the connection between the water and the fuel. When the amount of the biomass is less, then the risk of corrosion and contamination will also be smaller. Then harmful contaminants such as bacteria, sludge, fungi, and moulds do not adjacent to the walls of tanks and fuel system of the engine.

The resulting microscopic particles are burned and more impurities are removed by filtering. Elimination of all microbial contamination reduces the possibility of corrosion of the fuel tanks, pumps and injectors. A fuel filters are cleaner and load centrifuge drops significantly.

XBee fuel additive to neutralize and control the formation of sulphur oxides in the combustion process, which significantly reduces the formation of sulfuric acid and its corrosive effects on engine parts. In Fig. 3, cleaning action fuel additive XBee was presented [13].

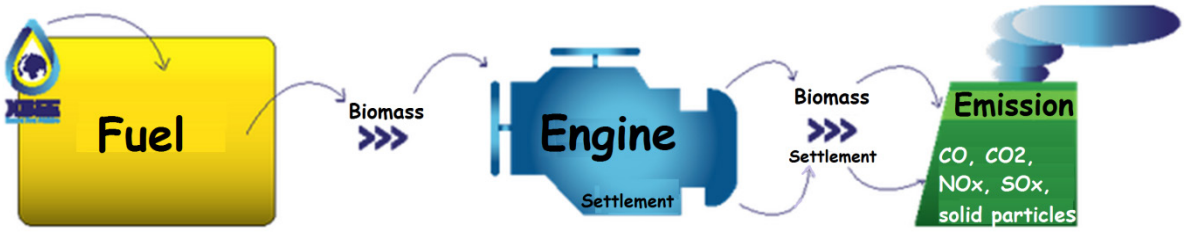

Fig. 3. Cleaning action fuel additive XBee [13]

Adding to the fuel cleaner XBee automatically eliminates all biological contaminants in the fuel and the fuel system. All these organisms are naturally burned with the fuel.

5. Simplified methods for determining the amount of microorganisms in the fuel

Apart from the measures that destroy microorganisms and additives, which have cleaning properties, are also simplified methods for determining the amount of microorganisms in the fuel using the kits containing the finished substrate suitable for growth of microorganisms. They can be used to monitor the microbiological status of petroleum products and thus prevent many accidents and take appropriate steps to reduce microbial contamination in petroleum products.

5.1. Detection of microorganisms using special kits

Simplified, but much faster and less expensive way to determine the amount of microorganisms in the fuel are commercially available special kits, which finished substrate suitable for growth of microorganisms, which are applied to fuel sample (e.g. MicrobMonitor2). The advantage of this solution is the simplicity of use test that can be performed by a person not familiar with laboratory practice [7].

Fig. 4. Detection of microorganisms using a special kit MicrobMonitor [12]

MicrobMonitor test kits are simple to use on-site, enable anyone for accurately, and reliably measure microbial contamination (Fig 4). Microbiological condition monitoring is the key to successful control of operational problems associated with microbial spoilage, fouling and corrosion in the aviation, marine, automotive, petroleum, power generation, offshore and engineering industries.

Microbial contamination caused aircraft to abort take off, ships to be taken out of service and power generator bearings to fail. Contamination can, if detected early, be treated and severe operational problems can be avoided. Routine condition monitoring as part of a good housekeeping regime can significantly improve asset utilisation and reduce operational risks. This test has a simple and safe way of assessing the numbers of colony forming units (CFU). CFU is the standard unit for measuring numbers of microbes [12].

5.2. Measuring the amount of microorganisms in a sample with an indication of the remedies

Another way to measure the amount of microorganisms is the use of quick and easy-to-use FUELSTAT™ test, which was developed in response to the needs of operators and companies repair and it enables testing at the petrol station (Fig. 5). This is a test, which allows accurate evaluation of the microorganisms' presence in the fuel tank, due to the use of two-component kit containing different quantities of the detecting contamination substance. This is a great convenience compared to tests based on the fungus growth, providing results only after 72 hours.

Research using the FUELSTAT™ kit provides a measurement of the amount of active spores in the sample with simultaneous indication of the remedies. It is more modern, faster and cheaper way of measurement than the old measurement of CFU, as previously used tests for the presence of microorganisms need to be carried out in accredited laboratories [14].

The development of effective methods of combating microbial contamination of fuels and oils, and its consequences for the installation of an internal combustion engine requires further research. The study should take into account both the technical aspects and the specifics of the processes occurring in the fuel and lubricating systems with the participation of microorganisms by means of environmentally friendly [11].

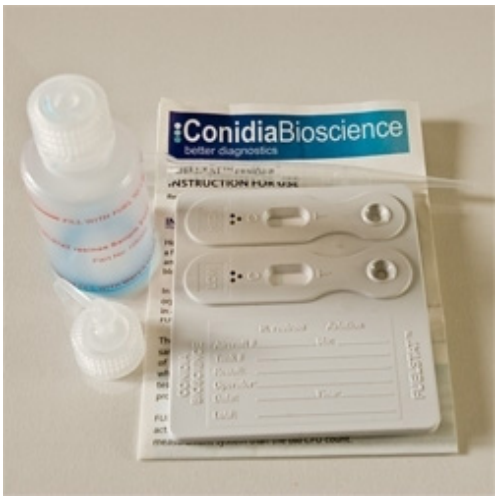

Fig. 5. Kit FUELSTAT™ do to study the of microorganisms with an indication of the remedies [14]

6. Proposals for other ways to combat or limit the growth of microorganisms

One way of combating microorganisms, including environmental aspects can be effective microorganisms (EM). They are complex cultures of beneficial microorganisms naturally occurring, non-genetically modified, they remain in a state of equilibrium, not only harmless to humans, animals and the environment, but also even necessary for their proper functioning. These are specially and suitably selected the smallest organisms on Earth. EM began to be used in horticulture, environmental protection, medicine, industry and many other sectors of the economy.

Photosynthetic bacteria, using available conditions for example CO_2, temperature, produce from organic matter or toxic gases useful active biochemicals.

The lactic acid bacteria slow the development of bacteria. Another important component of the mixture is the yeast. Thanks to the fermenting fungi, which degrade the organic matter and neutralization of unpleasant odours.

The operation principle of effective microorganisms is based solely on natural processes; they are not genetically modified and completely environmentally friendly. Currently, the most widely effective microorganisms are used in water treatment and wastewater and water reservoirs. This technology is also used in waste incineration plants, which significantly reduces emissions of dangerous dioxins.

In addition, the commonly is known heavy metals operation such as copper and silver in the combating of bacteria, fungi, viruses [6, 2].

Silver is a root used for a long time as a protective measure or medicinal products. Already in studies conducted during World War II, it was found that this metal destroying the germs of dysentery, cholera, typhoid and malaria. Silver is also used in the filters as well as for the purification of air and water from microorganisms in confined spaces such in airplanes. Silver ionisation method has helped to strengthen disinfectant action of the element. Ionization of silver, as well as ionization of copper, has been used in the elimination of certain bacteria. The positively charged ions of copper and silver when combined with the negatively charged cell walls of bacteria causing their lysis and consequently death. It has been shown that ionized form of silver and copper are capable of penetrating biofilms in water systems and limit the growth of microorganisms therein. Studies concerning antibacterial activity copper and silver ions in water hospital were carried out. It was found that the water samples supplemented with copper and silver ions there was a 30% reduction of bacteria and fungi compared to water, which did not contain these elements [11].

Silver is also used in the form of nanosilver. Shredded silver has a greater active surface area, thereby increasing its biocidal activity. Nano structures have sizes of nanometric that is from 0.1 to

100 nanometers. Nanosilver is able to join cell membranes of bacteria and block the production by the one enzymes necessary for propagation and growth.

Good carriers for nanosilver are activated carbon fibres (ACF – activated carbon fibre), widely used in sewage treatment plants for removing organic and inorganic impurities because of their large surface area, rapid adsorption and specific reactivity of the surface [8].

Sterilization ultrasonic – is a method of sterilization by using ultrasound waves at a frequency above 20 kHz. These waves, produced in generators, a very strong impact on living bacteria. The mechanism of action is based on ultrasonic cavitation, i.e. rupturing the cells from the inside as a result of gas bubbles production in the cell. Ultrasound is widely used, particularly for microbial cell disruption. There was special equipment constructed: ultrasound disintegrators – sonicators (e.g. Polish UDM-10 or British company MSE) very high frequency and power used to break up germ cells, yeast, etc. [13].

7. Conclusions

1. With the development of industry and the wider automotive industry, it turned out that the problem of microbial contamination is still valid and it becomes more commonplace. Research showed that the activity of microbial life could lead to interference and even damage engines of vehicles, aircraft or ship.
2. Physical methods are less burdensome for the environment, but unfortunately, their use is limited, inter alia, for this reason that it cannot be used with their help decontamination e.g. tanks. Therefore, other methods are used which include biocides, which are compounds of synthetic or natural origin for combating harmful organisms. They are also used detergents during storage of fuel, which help eliminate water, reducing deposits such as rust.
3. One way of combating microorganisms, including aspects of environmental protection can be effective microorganisms (EM), complex cultures of beneficial microorganisms found in nature. Another method of combating microorganisms may also be the use of silver ions or sterilization of microorganisms by using ultrasound.
4. It is necessary to develop effective methods for combating microbial contamination of fuels and oils, taking into account both the technical aspects and the specifics of the processes occurring in the fuel and lubricating systems by the means, which will be environmentally friendly.

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